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(54) **LOGICAL OPERATION UNIT FOR PACKET PROCESSING**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,648,254 A	3/1972	Beausoleil
4,296,475 A	10/1981	Nederlof et al.
4,791,606 A	12/1988	Threewitt et al.
4,996,666 A	2/1991	Duluk, Jr.
5,088,032 A	2/1992	Bosack
5,283,882 A *	2/1994	Smith et al.
5,319,763 A	6/1994	Ho et al.
5,383,146 A	1/1995	Threewitt
5,440,715 A	8/1995	Wyland
5,450,351 A	9/1995	Heddes

(List continued on next page.)

OTHER PUBLICATIONS

Jon P. Wade and Charles G. Sodini, "A Ternary Content Addressable Search Engine," IEEE Journal of Solid-State Circuits, vol. 24, No. 4, Aug. 1989, pp. 1003–1013.
 Teuvo Kohonen, content-Addressable Memories, 1987, pp. 128–129 and 142–144, Springer-Verlag, New York.
 Brian Dipert, ed., "Special-purpose SRAMs Smooth the Ride," EDN, Jun. 24, 1999, pp. 93–104.

(List continued on next page.)

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ABSTRACT

An apparatus and method for performing logical operations on information in the communications protocol stack, such as the transport layer (L4) port numbers, characterizing a received packet or frame of data in a data communications device such as a router or switch. The results of the logical operations, along with other packet/frame-identifying data, are used to generate a more efficient lookup key. A content addressable memory (CAM) lookup is used to determine the action indicated by the rules defined by a rule-based routing or switching scheme, such as an access control list (ACL). The results of these logical operations extend the key space and thus provide a finer-grained match between the original, unextended input key and a rule action, thereby pointing to a rule action precisely tailored to packet processing. The rule can thus be applied with fewer CAM entries, providing the versatility improvement and CAM cost reduction necessary to keep up with the ever-increasing rule complexity requirements of advanced data communication and internetworking systems. An embodiment utilizing asymmetrical processing of packets, depending on whether the packet is inbound to the data communications device or outbound from it, is also disclosed. Furthermore, a ternary content-addressable memory (TCAM) implementation is disclosed. Use of a TCAM for ACL or other rule lookups further enhances the efficiency of rule processing by providing a masking capability for each TCAM entry which can be used to provide an additional level of flexibility for rule element checking.

37 Claims, 16 Drawing Sheets

